Senior Thesis

Middle Ordovician Conodont Biostratigraphy of the Coburn Formation in Central Pennsylvania and its Correlation with the New York Standard Succession

by

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Submitted as partial fulfillment of
the requirements for the degree of
Bachelor of Science in the Geological
Sciences at the Ohio State University,
Summer Quarter, 1999

Approved by: _____
Dr. Stig M. Bergström

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ABSTRACT

Middle Ordovician conodonts have been little studied previously in central Pennsylvania. The present study of samples from a well-exposed section through the Coburn Formation near Reedsville produced a moderately abundant and not very diverse conodont fauna dominated by *Phragmodus undatus, Panderodus* sp., *Drepanoistodus suberectus,* and *Plectodina aculeata.* Important for the correlation of the uppermost Coburn is the occurrence of *Polyplacognathus ramosus,* which suggests an age no younger than the *A. tværensis* Zone. Based on conodont, graptolite, and K-bentonite evidence, the Coburn is correlated with a portion of the Flat Creek Member of the Utica Shale, and with the Shermanian part of the Trenton Group, of New York.

INTRODUCTION

The Ordovician outcrop area in central Pennsylvania (Fig. 1) is of major significance for the regional correlation between the Cincinnati and Mohawk Valley-Black River regions. The Cincinnati region of Ohio, Kentucky, and Indiana, which is the type area of the Cincinnatian (Upper Ordovician Series), and the Mohawk Valley-Black River region in north-eastern New York, which has been the type area of the Mohawkian (upper Middle Ordovician) Series are two of the most important outcrop areas of Ordovician rocks in North America. The present project deals with the spectacular section at Reedsville, Mifflin County, Pennsylvania (Rones, 1969; Thompson, 1963), the conodont biostratigraphy of which has not been investigated previously.

The Ordovician rocks in central Pennsylvania have up to now been less frequently investigated than those in the other two regions just mentioned and many aspects of their fossil faunas and stratigraphy are still poorly known. This applies to the stratigraphic interval of the present study, the upper Mohawkian (upper Middle Ordovician), now classified as the Chatfieldian Stage (Leslie and Bergström, 1994).

The only previous conodont investigations in the Chatfieldian succession of central Pennsylvania are unpublished theses (Valek, 1982; Leslie, 1995) from which some information has been used in a few published papers (Sweet, 1984; Kolata et al., 1996). The conodont research described herein is an extension of Valek's (1982) study, which was the first detailed investigation of the Ordovician conodont biostratigraphy in central Pennsylvania. Valek correlated the Salona and Coburn formations with the well-known sequences in north-central New York and the Cincinnati Region and integrated his work with Sweet's (1995) then-unpublished conodont-based composite standard for the

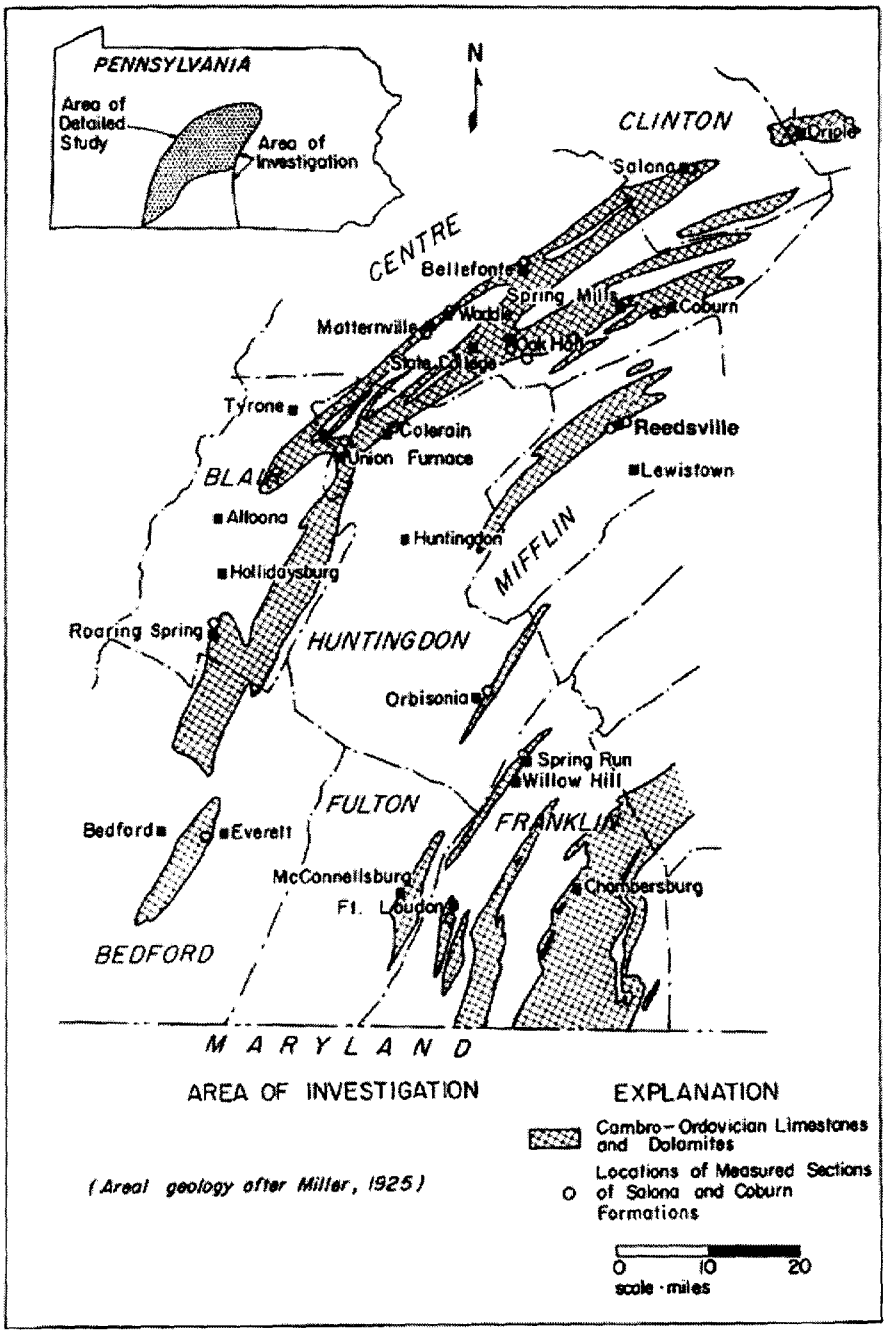

Fig. 1. Ordovician outcrop areas in central Pennsylvania (after Thompson, 1963). The section studied is just north of Reedsville.

Ordovician System of North America. The purpose of the present study is to clarify the relations between the conodont and graptolite biostratigraphy, and the K-bentonite stratigraphy in the Coburn Formation at a new long exposure of Chatfieldian strata at Reedsville. Of particular interest was to examine the relations between the Reedsville succession and equivalent strata in the New York standard succession.

THE REEDSVILLE SECTION

Thompson's (1963) used a composite of a road cut outcrop near Reedsville, and a drill core taken a short distance away. The road cut (Fig. 2) has been enlarged in recent years, exposing much more of the Chatfieldian interval. This spectacular exposure is located at the end of the Hwy 655 exit from SR 322, just west of the town of Reedsville (Fig. 3). The Coburn Formation in this outcrop consists of lime mudstone with occasional interbeds of bioskeletal calcirudite, calarenites, calcilutites, and calcareous shale (Fig. 4). The Salona-Coburn (Fig. 5) and Coburn-Antes (Fig. 6) contacts are quite clear and there are several prominent K-bentonite beds in these units (Fig. 7). Unfortunately, stratigraphic thickness cannot be measured for the entire Coburn Formation here due to an interval of heavy folding that also includes at least one major fault (Fig. 8).

PREVIOUS WORK

Taylor (1835) was the first to describe the Ordovician strata of central Pennsylvania. Rodgers (1858) and Collie (1903) subsequently published description of

Fig. 2. The Reedsville outcrop along the N-bound lane of SR 322, near the intersection with Hwy 655. The interval between the arrows represents the Coburn Formation.

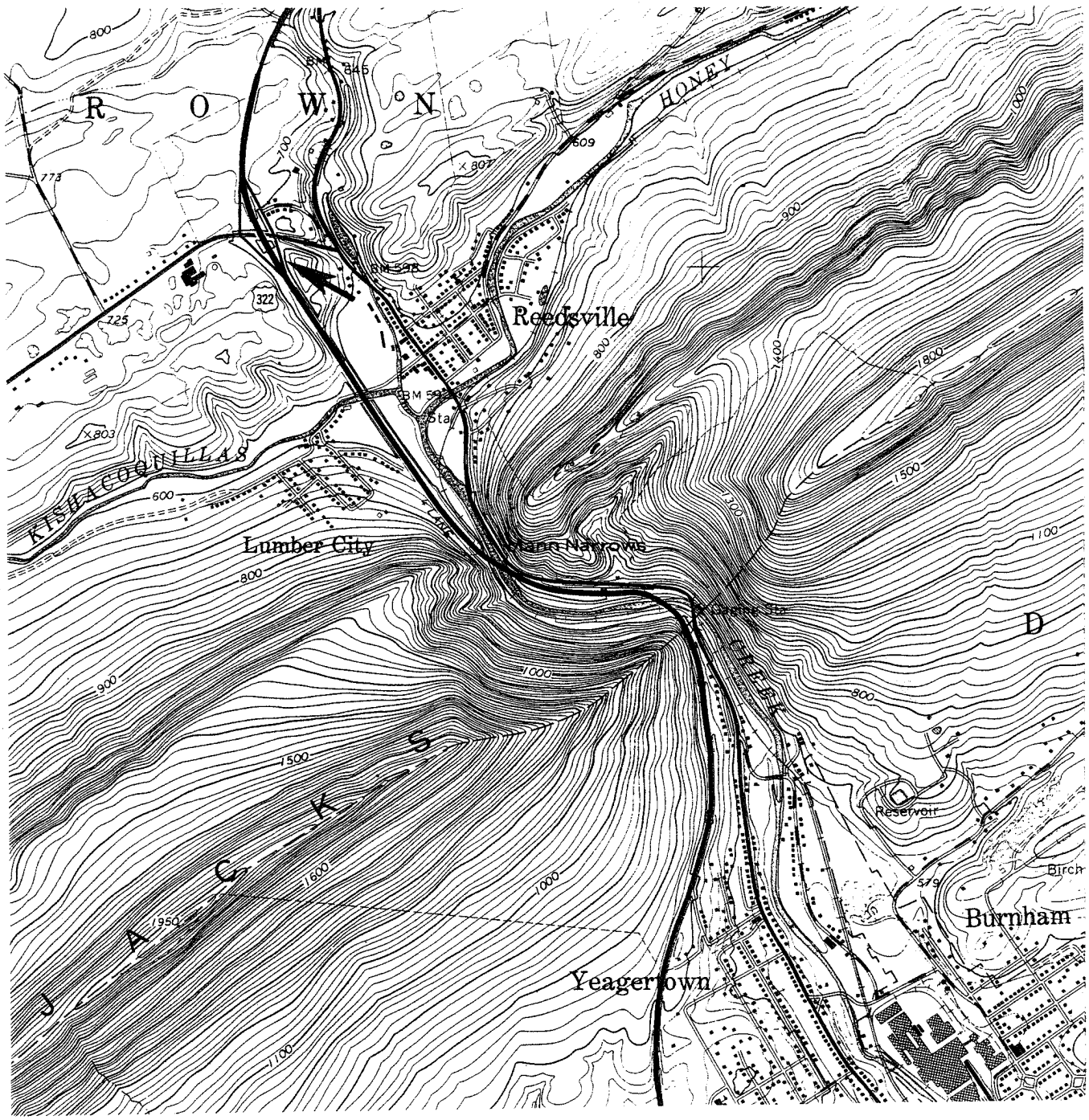

Fig. 3. Location map showing the position of the Reedsville highway cut (arrow). Map is part of the Burnham Quadrangle topographic map, scale 1:24000.

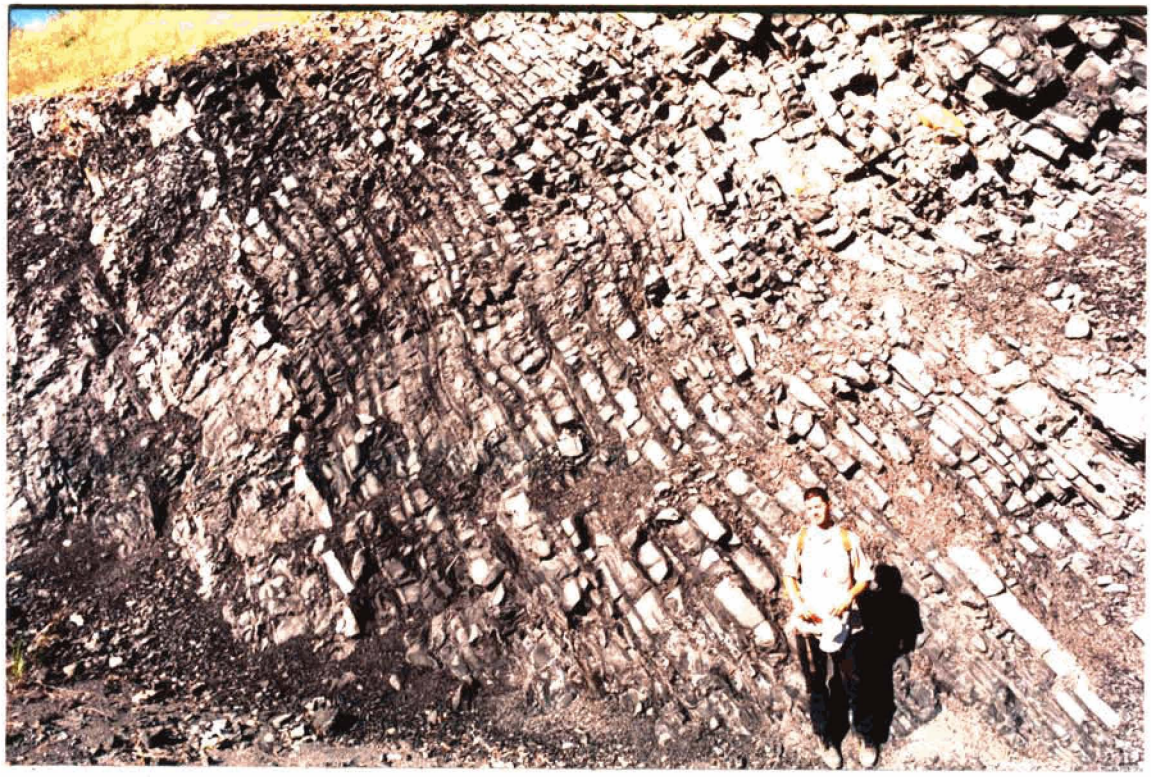

Fig. 4. Typical lithology of the Coburn Formation in the Reedsville section.

Fig. 5. The Salona/Coburn contact (marked by man holding hammer) in the Reedsville section.

Fig. 6. The Coburn/Antes contact in the Reedsville section. The topmost Coburn has been stained yellowish by iron-sulfur compounds from weathered pyrite in the basal Antes. The formation contact is probably faulted and may also represent a significant stratigraphic gap.

Fig. 7. Prominent K-bentonite bed in the Salona Formation in the Reedsville section.

Fig. 8. Fault and much folded rocks in the middle-upper Coburn in the Reedsville section. (cf. Fig. 13).

the area's lithologic units. Field (1919) named the upper unit of the central Pennsylvanian Trenton limestone succession the Coburn Formation. Whitcomb (1932a) correlated the Coburn with the Trenton in New York based on the occurrence of *Parastrophia hemiplicata*. The recognition of K-bentonite beds in the Ordovician of central Pennsylvania allowed the correlation between several sections in the area (see Honess and Bonine, 1929; Whitcomb 1932b; and Rosenkrans, 1934). Kay (1944) added the overlying Nealmont to the Trenton Group. Ten years later, Twenhofel et al. (1954) correlated the Coburn with the Cobourg in New York, and based on K-bentonite beds, Thompson (1963) divided the Coburn into upper and lower members, which he named the Milesburg and Coleville, respectively. Bergström (1971) considered the Coburn no younger than the Lower Denmark of New York on the basis of the occurrence of *Amorphognathus tværensis* and the distribution of K-bentonite beds. Later, based on data from Fetzer (1973), Sweet and Bergström (1976) suggested that the uppermost Coburn is lowermost Edenian, and the rest of the unit Shermanian. Valek (1982) concluded that the Coburn is mainly Kirkfieldian, with the exception of the uppermost Coburn at Bellefonte, which he considered earliest Shermanian. He also correlated the Coburn with the Lexington limestone in the Cincinnati region and the Kings Falls and lower half of the Sugar River Formations in the Trenton Group of New York. For a more detailed description of previous work, see Valek (1982) and Rones (1969).

GEOLOGIC SETTING

The Ordovician System is represented in central Pennsylvania by an 8,000 ft. thick sequence of rocks. This succession can be divided into three stratigraphic units.

The lower part is the 3,700 ft. thick Ibexian (Canadian) Series, which is mainly dolomite with lesser amounts of limestone. It is overlain by the 1,500 ft. thick Champlainian Series, which mainly consists of limestone. This is in turn overlain by 2,700 ft. of graywacke and sandstone that are referred to the Cincinnatian Series (Rones, 1969). The outcrop area of these rocks is located almost entirely within the Valley and Ridge Province of the Appalachian Mountains. Carbonates occur in eroded anticlinal valleys, creating arcuate exposures that trend roughly NE-SW. The Coburn Formation is the middle 275 feet of the Trenton Group, which is of latest Champlainian (Chatfieldian) age. Its basal part, the Milesburg Member, conformably overlies the Salona Formation. This member is characterized by interbedded *Sowerbyella* bioskeletal calcirudite and *Sowerbyella*-trilobite bioskeletal calcirudite with beds of calcarenites, calcilutites, and calcareous shale. The upper member, the Coleville Member, comprises laminæ of *Dalmanella* bioskeletal calcirudite and *Dalmanella*-crinoidal bioskeletal calcirudite, with interbeds of calcarenites, calcilutites, and calcareous shales (Valek, 1982). See Thompson (1963) for detailed lithologic descriptions of the Coburn and adjacent formations. The Coburn is unconformably overlain by the Antes Shale, which consists of black shale with many interbeds of argillaceous limestone.

METHODS OF STUDY

Seventeen samples were collected from the Reedsville section of the Coburn and Salona Formations (Fig. 9). These samples were processed during the spring and summer of 1999 in the Microfossil Processing Laboratory at the Ohio State University. The hand samples were crushed to fragments of less than roughly 2 cm across, with the exception

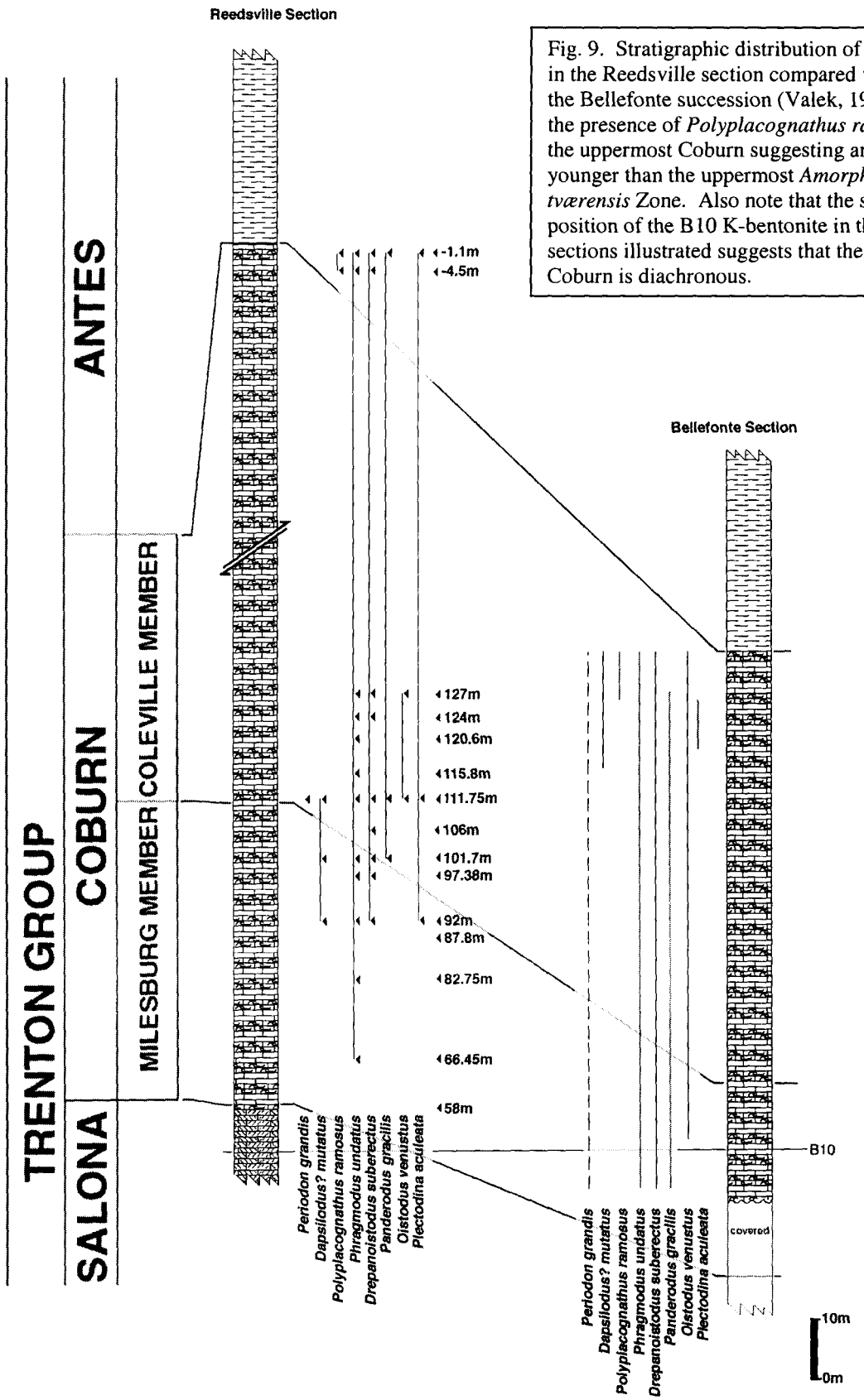

Fig. 9. Stratigraphic distribution of conodonts in the Reedsville section compared with that in the Bellefonte succession (Valek, 1982). Note the presence of *Polyplacognathus ramosus* in the uppermost Coburn suggesting an age no younger than the uppermost *Amorphognathus tværensis* Zone. Also note that the stratigraphic position of the B10 K-bentonite in the two sections illustrated suggests that the base of the Coburn is diachronous.

of one small reference sample of each. The crushed samples were then placed into a 10-15% solution of acetic acid. Once soluble materials had been digested, the insoluble portions were rinsed through A.S.T.M. 124 μ and 420 μ screens to remove fines and large, undigested pieces. The resultant residues were oven-dried and reduced by the removal of magnetically susceptible grains. This was accomplished with an isodynamic magnetic separator. Exceptionally large samples were further reduced by tetrabromoethane heavy-liquid separation, resulting in isolation of phosphatic residues from lighter constituents. Savage (1988) describes the steps involved in this type of separation. The final residues were then dry-brush picked under a dissecting microscope, sorted by sample, and finally identified and mounted on micropaleontologic slides using saliva. The distribution of identified conodonts in the Coburn samples is illustrated in Fig. 9 and listed in the Appendix. All the species found are well known from other sections and there is no need to re-describe them here.

CORRELATION

As might be expected from the lithology, conodont yield from the Coburn in this section is rather poor. Local and regional correlation cannot therefore be accomplished using conodont biostratigraphy alone. In order to correlate with other areas of interest, volcanic ash bed and graptolite fossil data have been incorporated into this study. The Chatfieldian succession in New York is of special interest in that it contains a remarkable succession of volcanic ash beds, which are referred to as K-bentonites (Goldman et al., 1994). Because K-bentonite beds are the deposits from very short-lived volcanic eruptions, they represent isochronous surfaces that, if they can be traced regionally, are of

exceptional value as time horizons (Kolata et al., 1996). For regional tracing of individual ash beds, one can use basically two methods: (1) biostratigraphic position; and (2) chemical characteristics of the ash. Both these methods have been used extensively in the New York succession (Goldman et al., 1994; Mitchell et al., 1994) where chemically fingerprinted beds have been tied into a detailed biostratigraphic framework based mainly on graptolites (Goldman, 1995) and conodonts (Schopf, 1966; Sweet, 1984; and Kolata et al., 1996).

The Chatfieldian succession in central Pennsylvania contains numerous K-bentonite beds (Kolata et al., 1996) but their precise relations to the New York K-bentonite succession have not yet been established. Chemical fingerprinting studies of individual ash beds, as well as graptolite biostratigraphic investigations, are currently underway (Mitchell, personal communication, 1999) in an attempt to tie the central Pennsylvania succession to the coeval interval in New York and the present conodont study may be considered a compliment to this effort.

The Reedsville section contains several K-bentonite beds, and provides an excellent outcrop of the Salona, Coburn and Antes Formations.

Comparison with the Bellefonte and Roaring Springs Sections

Comparison of conodont species ranges in the Reedsville Section with those of the Bellefonte and Roaring Springs Sections provides some useful information. The presence of *Polyplacognathus ramosus* in the upper 10 m of the Coburn indicates that the uppermost Coburn at these localities is of approximately the same age(Fig. 8). Furthermore, because this species is essentially restricted to the *A. tværensis* Zone, its

presence in the topmost Coburn suggests that this unit is not younger than this conodont zone. The Reedsville section can be divided into five informal assemblage zones based on the lowest appearance of conodont species (Fig. 10). Using lowest occurrence eliminates the problem of reworking of specimens into higher strata and provides a minimum possible age for the zone boundaries. Zone 1, from 14.45 to 40 m contains *Phragmodus undatus.* Zone 2, from 40 to 49.7 m is defined by the appearance of *Dapsilodus mutatus, Drepanoistodus suberectus,* and *Plectodina aculeata.* Zone 3, from 49.7 to 59.75 includes all of the above species in addition to *Panderodus gracilis.* Zone 4, based on the appearance of *Periodon grandis,* and *Oistodus venustus,* and is marked by the disappearance of *Dapsilodus mutatus* from the assemblage, is from 59.75 to the 4.5 m below the Coburn-Antes interface. Zone 5, in the uppermost 4.5 meters of the Coburn, is marked by the appearance of *Polyplacognathus ramosus.* It should be noted that the conodont species found in the Coburn of the Reedsville section have somewhat different total stratigraphic ranges than the same species at Bellefonte. Hence, the ranges recognized in my collections may be of only local significance. Also, the number of specimens is small in most of the samples studied, and it is likely that with larger and more closely spaced samples, the conodont distribution pattern in the Reedsville section would be slightly different.

Valek (1982) recognized one K-bentonite bed at both his localities, namely B10 (Thompson's B-R). This bed is traced to the Reedsville Section by chemical fingerprinting and provides a time surface, indicating that the upper middle Milesburg Member at Bellefonte and Roaring Springs are coeval with the upper Salona at Reedsville, as illustrated in Fig. 9. Several other K-bentonite beds are exposed in the

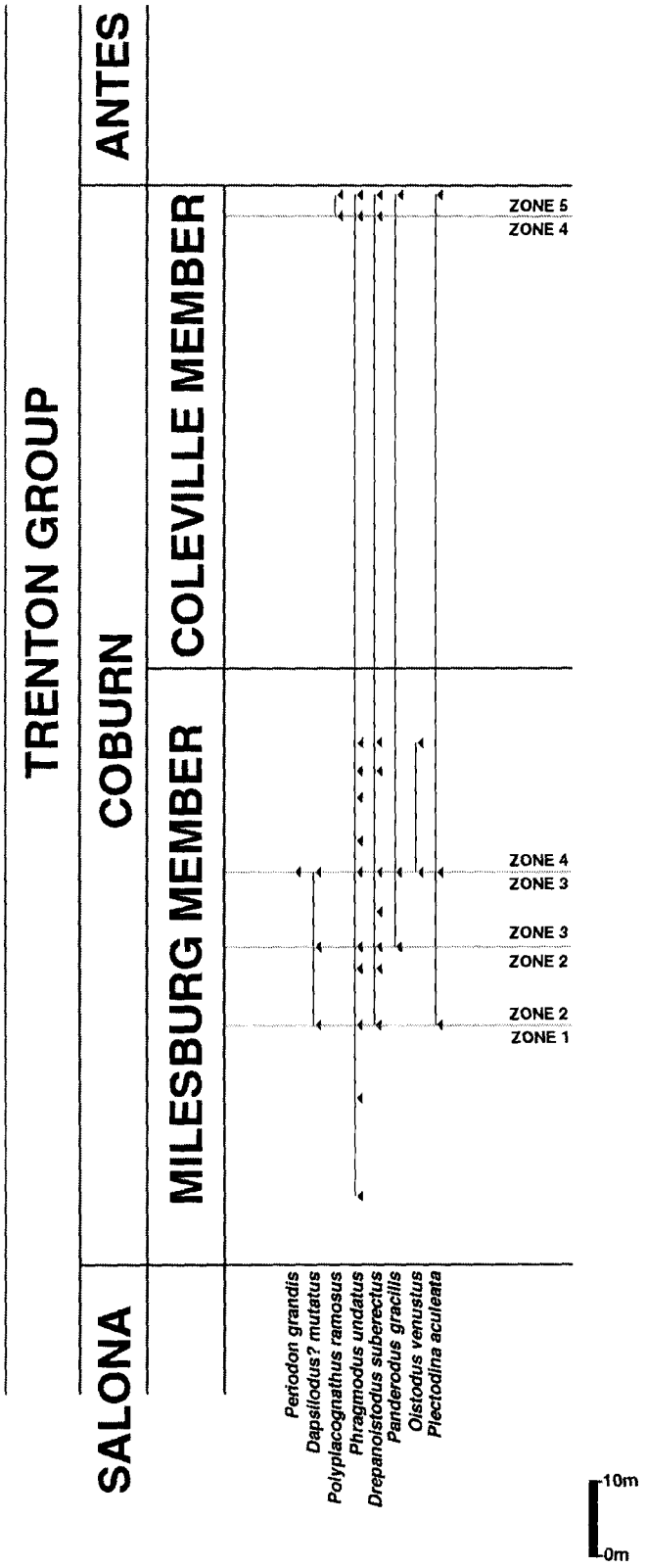

Fig. 10. Informal conodont assemblage zones in the Coburn of the Reedsville succession.

Reedsville Section, and the tracing of these beds to Bellefonte and Roaring Springs in future studies will allow more detailed correlation.

Comparison with the New York Composite Section

The farther from the Reedsville Section, the more tenuous conodont-based correlations can be, given current data. The New York Composite Section can be divided into eight informal assemblage zones based on lowest occurrence of species (Fig. 11). Zone 1 contains *Phragmodus undatus, Rhodesognathus elegans, Panderodus sp., Drepanoistodus suberectus,* fibrous conodonts, *Belodina compressa, Plectodina* spp., *Aphelognathus* sp. A, *Icriodella superba,* and *Amorphognathus tværensis,* although *Aphelognathus* sp. A is only present in the lower portion of the zone. Zone 2 is defined by the appearance of *Dapsilodus variabilis,* and marked by the reappearance of *Aphelognathus* sp. A. Zone 3 is defined by the appearance of *Polyplacognathus ramosus,* but otherwise contains all the species found in Zone 2. Zone 4 is defined by the appearance of *Yaoxianognathus abruptus,* which also disappears in the upper middle portion of the zone along with *Aphelognathus* sp. A. Zone 5 is defined by the reappearance of *Amorphognathus tværensis. Icriodella superba* also reappears in this zone and *Belodina compressa* disappears. Zone 6 is the lowest occurrence of *Periodon grandis* and contains all the species in Zone 5 with the exception of *Polyplacognathus ramosus.* Zone 7 is defined by the appearance of *Coelocerodontus trigonius.* Zone 8 is defined by the appearance of *Amorphognathus superbus* and the disappearance of *Amorphognathus tværensis* and is marked by the disappearance of *Dapsilodus variabilis.*

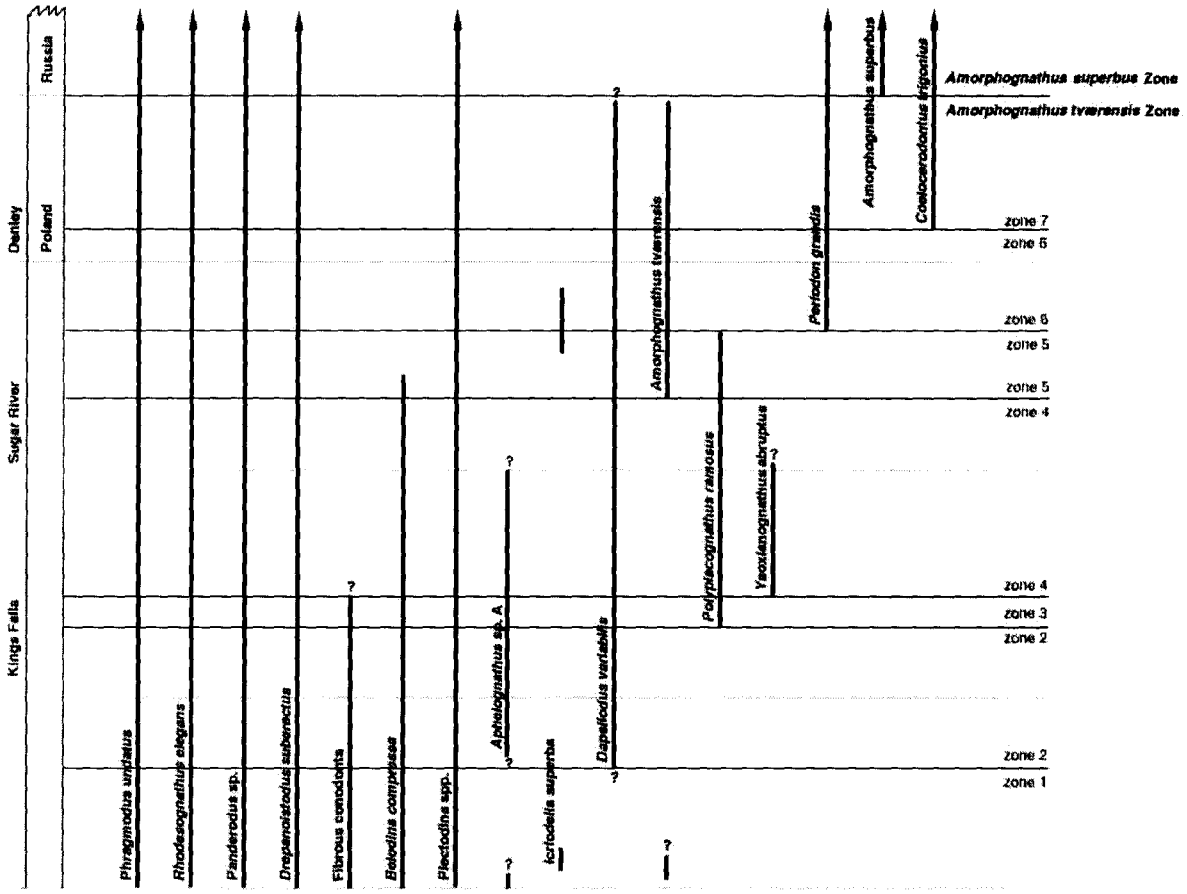

Fig. 11. Informal conodont assemblage zones in the New York succession. Based on Schopf (1966).

The New York conodont distribution in these zones indicates that the lowermost Coburn at Reedsville is no older than the lower middle Kings Falls Formation in New York.

For a long time, K-bentonites have been recognized in several Middle Ordovician formations in central Pennsylvania (Rosenkrans, 1934; Kay, 1944; Thompson, 1963; Rones, 1969; Kolata et al., 1996). The Nealmont Formation contains six persistent ash beds, five of which have been traced through the outcrop belt based on unique chemical signature (Cullen-Lollis and Huff, 1986). Several K-bentonites have also been recognized in the Coburn (Thompson, 1963) but these have not yet been subjected to chemical fingerprinting studies.

In the Reedsville section, there are two ash beds in the lower Antes Shale, just above the top of the Coburn (Figs. 12 and 13), that based on chemical fingerprinting are correlated with the Manheim and East Canada Creek K-bentonites in New York (Mitchell, personal communication 1999). These Antes ash beds occur in the lowermost *C. spiniferus* Zone, and in terms of graptolite biostratigraphy, they occupy the same stratigraphic position at Reedsville as in the New York succession (Fig. 14).

No graptolites have yet been reported from the Coburn but these fossils have long been known from the overlying Antes Shale (Kay, 1944). Recent work (Mitchell, personal communication 1999) shows that the basal 1.5 m of the Antes Shale at Reedsville has graptolites of the *C. americanus* Zone (Fig 13). A 3.4 m thick interval above this unit contains graptolites of the *O. rudemanni* Zone, and superjacent strata have yielded faunas of the *C. spiniferus* Zone. The graptolite biostratigraphy of the upper Antes shale has not yet been investigated. The biostratigraphic significance of these data is that clearly, the top of the Coburn is older than the uppermost *C. americanus* Zone.

Fig. 12. The Manheim Ash (K-bentonite) bed (marked by field book) in the Antes at the Reedsville section. This K-bentonite is identified with the typical Manheim of New York based on chemical fingerprinting and biostratigraphic position. The black shales above and below this ash bed at Reedsville yield graptolites of the *C. spiniferus* Zone

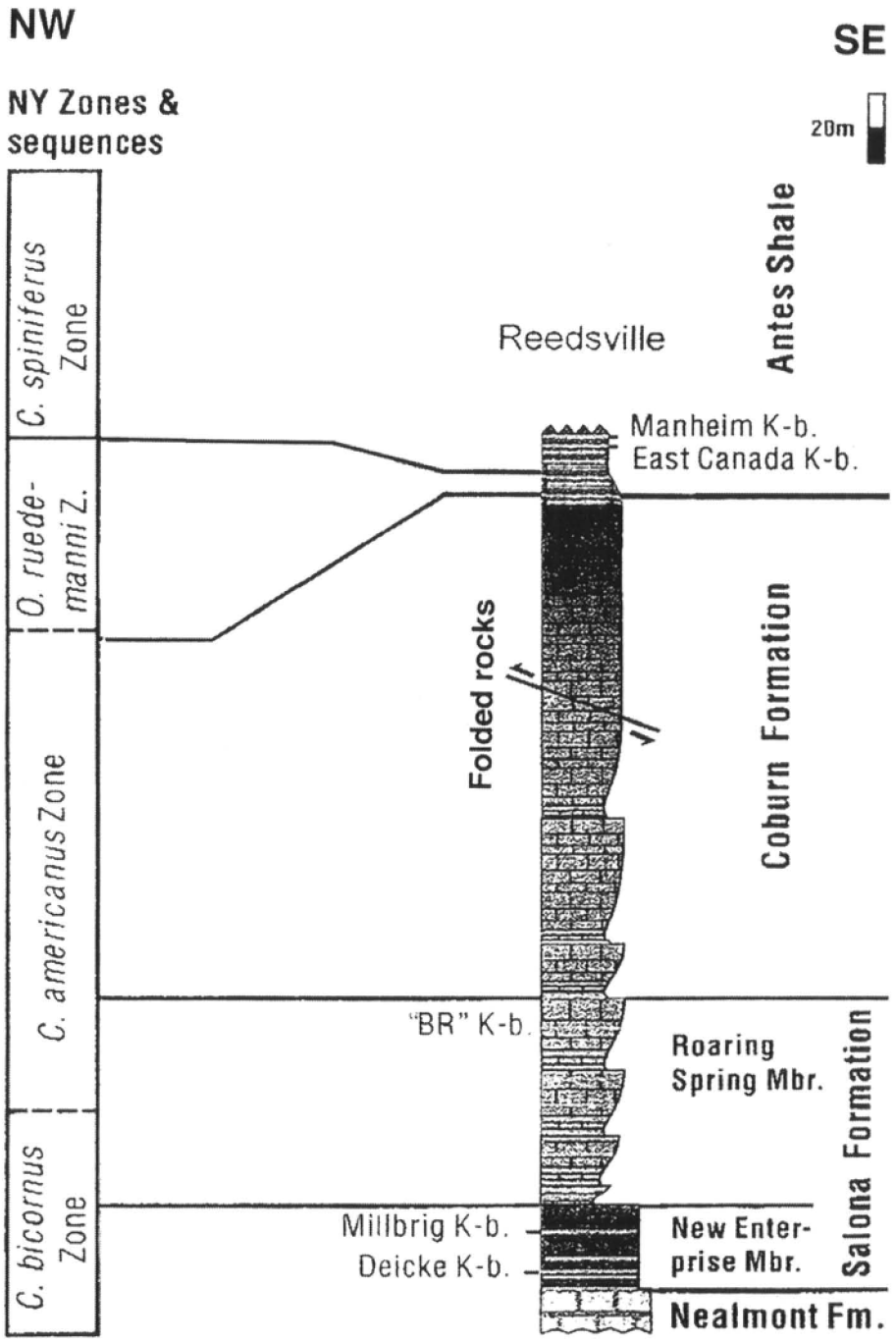

Fig. 13. Stratigraphic position of some key K-bentonite beds in the New York succession (Mitchell, unpublished). Based on K-bentonite, graptolite, and conodont stratigraphy, the Coburn at Reedsville appears to correlate with part of the lower Flat Creek Member of the Utica Shale in the New York succession.

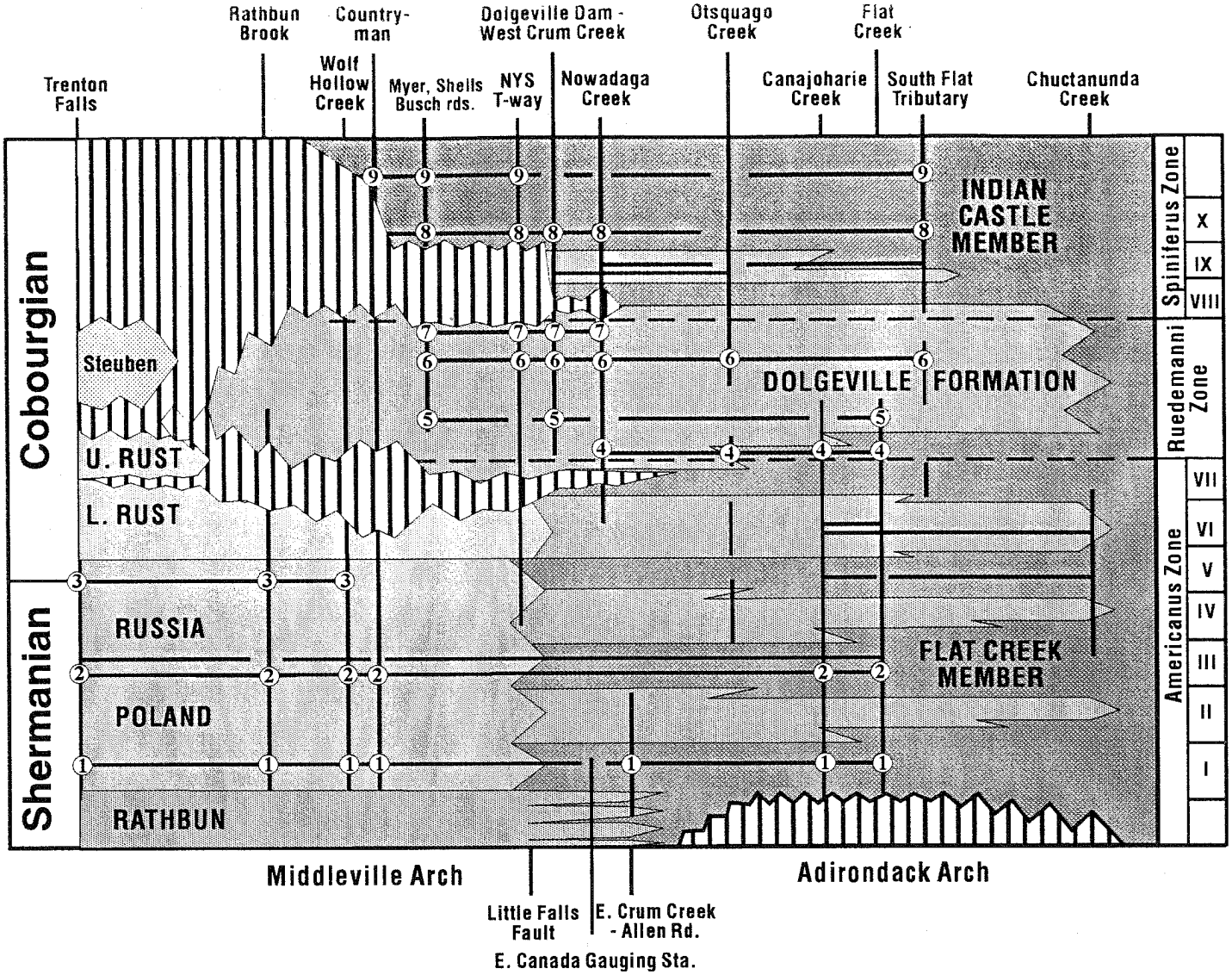

Fig. 14. New York diagram showing the position of the Manheim and E. Canada K-bentonite beds in terms of graptolite zones. 1) Sherman Falls Ash. 2) Wolf Hollow Ash. 3) High Falls Ash. 4) Spring Street Ash. 5) Smalls Bush Ash. 6) East Canada Ash. 7) Manheim Ash. 8) Thruway Ash. 9) Countryman Ash.

Regional comparisons suggest that most, if not all, of the Coburn corresponds to the *C. americanus* Zone, the base of this zone probably being coeval with a still still-undetermined level in the non-graptolite Roaring Spring Member of the Salona Formation (Fig. 13). The K-bentonites in the Antes and Coburn, as well as the graptolites in the basalmost Antes, show that the top of the Coburn is older than the upper Cobourgian of New York. Based on the graptolite evidence, the top of the Coburn is unlikely to be younger than the Rust in the New York succession, and it could be considerably older. The unconformity at the top of the Coburn (Fig. 6) may well represent a significant stratigraphic gap but if this is tectonic and/or stratigraphic cannot be determined on the basis of the evidence at hand.

CONCLUSIONS

Based on conodont, graptolite, and K-bentonite data, the uppermost Coburn in Bellefonte, Roaring Springs, and Reedsville are coeval, but the upper middle Milesburg Member at Bellefonte and Roaring Springs are coeval with the upper Salona at Reedsville. The lowermost Coburn at Reedsville is no older than the lower middle Kings Falls Formation (Shermanian) in New York. The lowermost Antes in the Reedsville Section is coeval with the upper Flat Creek Member of the Utica Shale in the New York succession, making the top of the Coburn at Reedsville, now tied with that at Bellefonte and Roaring Springs, older than, and perhaps entirely encompassed by, the uppermost *C. americanus* Zone. The top of the Coburn is clearly older than the upper Cobourgian of New York and is unlikely to be younger than the Rust in the New York succession, and it could be considerably older. The evidence from the Reedsville Section from conodonts,

graptolites, and K-bentonites is in good agreement with the relations in the New York succession but further studies are needed in other sections in central Pennsylvania to establish the precise correlation of the Coburn in terms of standard New York stratigraphic units.

ACKNOWLEDGEMENTS

I am indebted to Dr. Stig M. Bergström, who proposed and supervised the project, and spent substantial amounts of his time giving assistance and advice without which this study could not have been conducted. I am also indebted to Dr. Charles E. Mitchell, who supplied unpublished information on the K-bentonites and biostratigraphy of the areas of study. A grant from "The Friends of Orton Hall Fund" defrayed field and laboratory expenses. Lastly, I'd like to thank Stella, upon whose strength and support I've come to rely.

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APPENDIX: Conodonts in the Reedsville Samples

99NBRe-62
99NBRe-66.45
- *Phragmodus undatus* (1)

99NBRe-82.75
- *Phragmodus undatus* (1)

99NBRe-87.8
99NBRe-92
- *Phragmodus undatus* (20)
- *Drepanoistodus suberectus* (2)
- *Dapsilodus mutatus* (4)
- *Plectodina aculeata* (2)

99NBRe-97.38
- *Drepanoistodus suberectus* (8)
- *Phragmodus undatus* (4)

99NBRe-101.7
- *Phragmodus undatus* (19)
- *Drepanoistodus suberectus* (5)

99NBRe-106
- *Drepanoistodus suberectus* (1)

99NBRe-111.75
- *Panderodus gracilis* (13)
- *Dapsilodus mutatus* (15)
- *Drepanoistodus suberectus* (5)
- *Oistodus venustus* (3)
- *Phragmodus undatus* (64)
- *Periodon grandis* (4)
- *Plectodina aculeata* (3)

99NBRe-115.8
- *Phragmodus undatus* (3)

99NBRe-120.6
- *Phragmodus undatus* (1)

99NBRe-124
- *Dapsilodus mutatus* (1)
- *Drepanoistodus suberectus* (1)
- *Phragmodus undatus* (24)

99NBRe-127
- *Phragmodus undatus* (41)
- *Panderodus gracilis* (8)
- *Drepanoistodus suberectus* (1)
- *Oistodus venustus* (5)
- *Pseudooneotodus mitratus* (1)

99NBRe-135.5
- *Phragmodus undatus* (50)
- *Drepanoistodus suberectus* (10)

Polyplacognathus ramosus (7)

99NBRe-138.9

Plectodina aculeata (1?)
Phragmodus undatus (23)
Drepanoistodus suberectus (6)
Panderodus gracilis (1)
Icriodella superba (1?)
Polyplacognathus ramosus (5)